883. Relation between the railroad noise and the social-economic factors

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Abstract. This paper provides recently, due to the increasing speed and intensity of trains traveling on railways, the noise caused by trains to the environment has greatly increased. As for example, in the Lithuanian Railway lines are unqualitative and due to such and other reasons a noise level near the passing railway line is rather high and reaches 110 and more dB(A). In other countries, such as Switzerland during the daytime, 1.5 % to 6.6 % are exposed to similar levels of railway noise, but 8 % to 27 % to road noise and at night 1 % to 4 % are exposed to rail, but 8 % to 32 % to road noise.

This paper the noise caused by moving trains may have diverse impact on people living not far from the railway lines and to affect a person both, psychologically and physiologically. A range of exposure-effect relationships of noise exposure and parameters of health and well-being such as self-reported health status, satisfaction with health, sleep disturbances, the intensity of the wish to move from the current residence as well as the awareness of "noise problems" at the place of living were investigated These studies are of Lithuania railway line Vilnius – Klaipėda Giruliai town villlage. The paper demonstrates that while solving the issue related to the reduction of the noise caused by trains, it is necessary to assess social and economic factors related to the noise caused by trains within the railway systems. The economic valuation of rail transport is economic valuation is very limited. This is primarily because compared to road and aviation transport, noise pollution of rail transport is seen as less importance.

Noise annoyance causes social and economic costs which are incorporated in various stages of the causal model. These measures can be subdivided into noise regulation and direct prevention measures. Stricter threshold values lead to higher total costs, but may lover social costs per capita. Economic feasibility of policy measures is usually analyzed by means of a cost-benefit case study. Methods of analysis used are diverse and hoc. Therefore, results of different case studies are not easily compared in terms synthesis.

Keywords: railway noise, impact people living, social-economic.

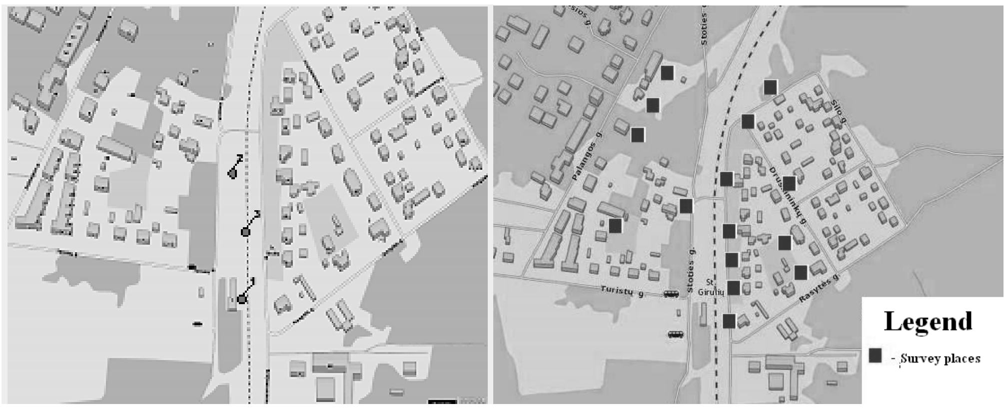
1. Introduction

At every stage of life, health is determined by a multitude of interactions between social and economic factors, genetic predispositions, the physical environment, and individual behavior. Such factors can be referred to as key determinants of health. As regards the physical environment, noise is one of the most widespread sources of environmental stress in everyday living.

Sound environment is an important part of the overall environmental sustainability. The aim of this study is to investigate the relationships between railway noise levels, especially in settlement, and selected social–economic factors; Noise, defined as unwanted sounds, could affect people both psychologically and physiologically [1, 2], with reported effects including cardiovascular stimulation, hearing loss, increased gastric secretion, pituitary and adrenal gland stimulation, suppression of the immune response to infection, as well as female reproduction and fertility [3-6]. The World Health Organisation (WHO) recommended that noise levels within hospital wards should not surpass 30 dBA in terms of sleep disturbance [7]. Since the 1960s the average noise levels inside hospitals have increased by an average of 0.38 dBA (day) and 0.42 dBA (night) per year [8]. The effects of various social and economic factors on the noise evaluationhave been intensively studied. In this research, 28 factors, which might affect noise assessments based on 2011 year research. The statistical software was used for the data analysis. For the investigation of how noise levels and social-economic factors are related. Correlations between the environmental noise levels and social-economic factors. Solving the economic problems associated with environmental noise was used "Global sunspots in OLG model".

2. Noise effects in humans

It was investigated the effects of nocturnal railway noise on sleep and cardiovascular response in young and middle-aged adults living for many years either near a railway track or in a quiet are. Sleep and cardiovascular modifications were assessed in response to noise. We have audited the passing train noise and vibration impact on people living near the railway health. For that purpose under the program linked here has been carried out population surveys. Recriument of subject survey site is shown in Figure 1. Giruliai local town residents have long been concerned about the traffic noise. They complain about the noise as well as access to public and public institutions.



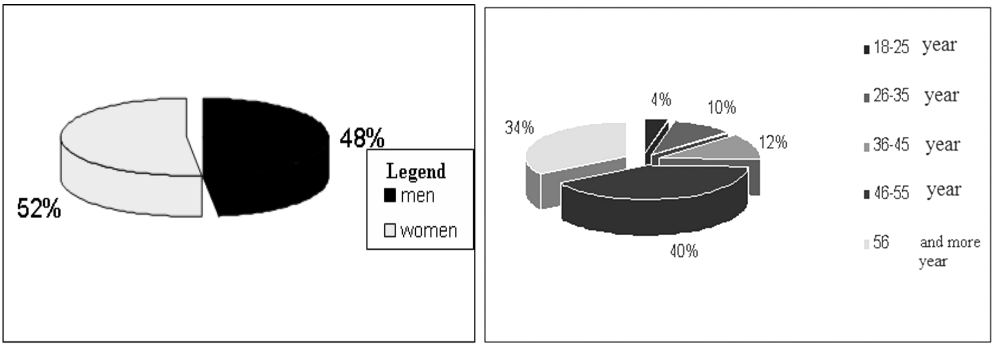
a) b)

Fig. 1. Giruliai village of Klaipėda city: a) 1 - Giruliai train station, 2 - Noise measurement places, 3 - Trains track, b) Subjects living near the rail track

The main sources of noise in the village are Giruliai passenger and freight trains and warning signals. Other sources of noise Giruliai not harmful and does not exceed the sanitary norms. The present study was designed to explore the effects of permanent exposure to nocturnal railway noise on sleep and cardiovascular reactivity in young and middle-aged subjects.

The side effects of noise and vibration created by the passing of trains have been researched in settlement areas and the Republic of Lithuania, have been analyzed (see Fig. 2 and Fig. 3). The empirical investigation of the noise has been carried out in the natural surroundings;the level of noise has been measured according to its spectrum and time. The effects of noise and vibration on the quality of human life have also been defined using the methods of inquiry and interview. The results of the investigation heve been analyzed and assessed according to the magnitude of the parameters and the producted effects on the residents. Sleep fragmentation indices were lower in RW subjects compared to QE whatever their age. In response to noise, there was a higher cardiovascular response rate surroundings; the level of noise has been measured acourding to its spectrum and time; onal significance, which progressively turns to habituation in the long-term if no adverse effect is experienced.

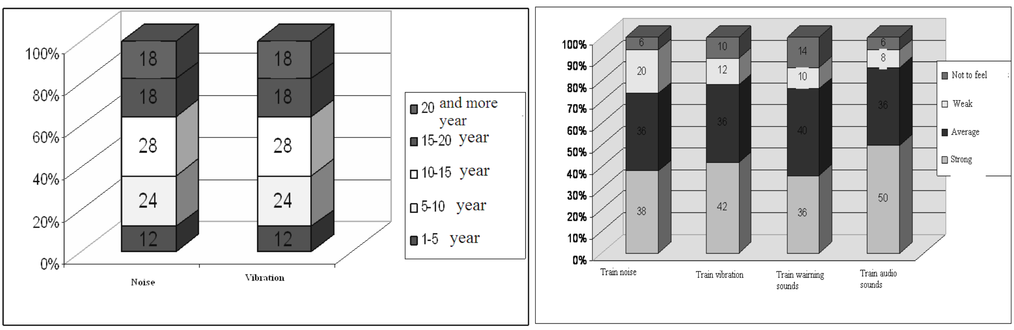
Nocturnal exposure to traffic noise leads to frequent complaints about chronic sleep disturbances and negative effects on quality of life. Recently, several studies reported important deleterious effects of nocturnal railway noise on sleep architecture and cardiovascular reactivity. This could be partly due to the fact that railway noise although ranging in a composite frequency band, involves usually an important power in the low frequencies known to be rather harmful.



a) b)

Fig. 2. Demographic data of the sample subject near a rail track:
a) sex of the respondents, b) age of the respondents

Survey participants were women 52 % and 48 % - men (see Figure 2a). It should be noted that the survey, women showed greater activity meant the comments, telling theirexperiences The oldest age group most people complain about noise-induced insomnia, headaches, high blood pressure. Middle age group also represents a dissatisfaction with sleep disturbances,vibrations, building construction and home-made problems. The younger generation is concerned frequent awakening during the night the noise caused by passing trains. Obtain the responsesshown in percentage terms.



a) b)

Fig. 3. Depending on the population: a) residential duration; b) habitual noctural expsure

As expected, our results suggest that living in the vicinity of railway tracks produces habituation to nocturnal noise on sleep architecture. This is reflected by fewer disturbances in all the sleep fragmentation indices induced by nocturnal train pass-bys on the sleep EEG in subjects who habitually live near rail tracks.

3. Noise annoyance has detrimental social and economic consequences

Economic growth and land use policy cause a situation where noise from surface and airborne traffic is an ever-increasing burden on the residential environment. Noise does not only generate a reduction of the sense of wellbeing of those affected, but also causes property value depreciation. As a result, noise annoyance has become one of the most serious forms of environmental pollution in industrialized economies. Noise pollution is an economic externality, and since silence does not have a market price, it is necessary to deduce its price indirectly. Therefore, determining an appropriate compensation fee is a complicated matter.

Railway noise is a complex phenomenon. The purpose here is to study the relationships between the components of the railway noise chain, and to identify opportunities for the government to use these relationships in noise prevention. Furthermore, the trade-off between damage costs and noise prevention by the government is discussed. This includes a literature survey on valuation of railroad noise pollution.

Social effects involve both psychological and physiological health problems. Economic effects are manifold and diverse but they are always economic costs. Economic costs may result from social consequences. Railway noise may have a negative effect on property values. Moreover, noise limit values put restrictions on construction plans in the vicinity of the railroad track. Reducing such economic effects or meeting noise limit values involves costs. Sometimes, the feasibility of noise reduction measures is assessed by a cost-benefit analysis.

Government policy on noise annoyance is primarily directed along two lines of measures. First, governments can use regulation of noise emission and immission standards and limit values. This includes regulation of noise measurement and methods. Second, governments can use direct policy measures to reduce noise emission and immission and provide incentives to private agents, such as railway operators and residential developers, to apply such measures. An example is the construction of noise control barriers. That residential areas are relatively dense around railway tracks explains the relatively large increase of annoyance as a result of higher noise levels.

4. Social - economic factors calculation model: “Global sunspots in OLG model“

Before going into details it is convenient to introduce some notation and terminology. The starting point of the two-sample test mentioned above is a squared distance between two probability distributions, μ and μ' on R^m, given by:

$$Q = \langle \mu - \mu', \mu - \mu' \rangle = \langle \mu, \mu \rangle - 2\langle \mu, \mu' \rangle + \langle \mu', \mu' \rangle, \tag{1}$$

where $\langle \cdot, \cdot \rangle$ is an inner product on the space of integrable functions. If one defines, for any pair v and v' of signed measures, the bilinear form:

$$(\nu, \nu')_h = \iint e^{-\|x-y\|^{2/(4h^2)}} d\nu(x) d\nu'(y), \tag{2}$$

where $\|\cdot\|$ is the Euclidean norm in R^m, this form turns out to have the properties of an inner product on the space of finite measures. That is:

$$Q_{\mu,\mu'}(h) = \langle \mu - \mu', \mu - \mu' \rangle \tag{3}$$

for each fixed positive bandwidth h has the usual properties of a squared distance between μ and μ', and in particular it satisfies $Q_{\mu,\mu'}(h) \geq 0$ with equality if and only if μ and μ' are identical probability measures. Since the integrals can be expressed as expectations, e.g.:

$$(\mu,\mu)_h = \iint e^{-\|x-y\|^2/(4h^2)} d\mu(x) d\mu(y) = E\left[e^{-\|X-Y\|^2/(4h^2)} \right], \quad (4)$$

where X and Y are independent and distributed according to the probability measure μ, they are similar to usual correlation integrals, but with a Gaussian kernel instead of the Heaviside kernel. Therefore $\langle \mu,\mu \rangle_h$ is known as the Gaussian kernel correlation integral of μ (with the bandwidth h playing the role of the length scale). Similarly, $\langle \mu,\mu \rangle_h$ is called the Gaussian kernel cross-correlation integral of μ and μ'. The Gaussian kernel correlation integrals can be estimated in a natural way from a pair of samples $\{X_t\}_{t=1}^{n_x}$ and $\{Y_t\}_{t=1}^{n_y}$ from μ and μ', respectively, by using U-statistics. Denoting:

$$C^{XX}(h) = \langle \mu,\mu \rangle_h, \;\; C^{YY}(h) = \langle \mu',\mu' \rangle_h \text{ and } C^{XY}(h) = \langle \mu,\mu' \rangle_h, \quad (5)$$

the U - statistic for $C^{XX}(h)$, for instance, is:

$$C_{nX}^{XX} = \frac{2}{n_X(n_X-1)} \sum_{i-2}^{n_X} \sum_{i-1}^{i-1} e^{-\|X_i-X_j\|^2/(4h^2)}. \quad (6)$$

The invariant measure of the perturbed system remains close to that of the underlying deterministic attractor, in the sense that the measure is perturbed only moderately by the noise (the states are unlikely to be found very far from the original attractor). The quadratic form $Q_{\mu,\mu'}(h)$ is a measure of distance, or divergence, between the probability distributions μ and μ'. One might therefore ask whether this quadratic form can be used to decide empirically (i.e. from time series data of clean and noisy state variables) whether a stochastically perturbed attractor with probability measure μ' on the state space, is a sufficiently moderate perturbation of the clean attractor measure μ to be considered a SSE around the clean attractor measure. Clearly, the measures μ and μ' are allowed to differ, so that a test for strict equivalence between μ and μ' is too restrictive for the present purpose. However, for (Gaussian) observational noise, which also perturbs the attractor in a moderate way, the following inequality can be derived for the correlation integrals:

$$C^{XY}(h) \geq C^{YY}(h). \quad (7)$$

In words, the cross-correlation integral of the noisy and the deterministic attractor is at least as large as the correlation integral of the noisy attractor. This inequality is derived under the assumption that the underlying noise free attractor has dimension $D < m$, and by using the expressions given [7] in for correlation integrals perturbed by observational noise. Although (7) is derived assuming that the noisy attractor is obtained from the deterministic attractor by adding observational noise, one can expect it to hold also for other moderate perturbations of the attractor. At the same time the inequality is not trivially satisfied for any pair of measures. For instance, it does not hold for small bandwidths if μ and μ' have disjoint supports. Therefore, for a given pair of measures μ and μ', whether the inequality holds or not can be viewed as a proximity notion for the two measures that closely coincides with the type of closeness that

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have to the underlying deterministic attractor. This motivates investigating if this proximity notion can be used to detect the presence or absence of empirically. The potential use of Eq. (7) for identifying is examined here by calculating correlation integrals from bivariate time series for different types of sunspot equilibria described by Gazzola and Medio. Since in general, due to the positive definiteness of the quadratic form:

$$CC^{XY}(h) \leq 0{,}5C^{XX} + 0{,}5C^{YY} \leq C^{XX}(h). \quad (8)$$

If the perturbed measure is sufficiently 'close' to the underlying attractor one should find:

$$C^{YY}(h) \leq C^{XY}(h) \leq C^{XX}(h). \quad (9)$$

Fundamentals correlation integrals and cross-correlation integrals obtained from samples of state variables for the deterministic dynamics. Apart from a deviation for the fixed-point attractor for very small values of the bandwidth h which may be attributed to estimation error, the cross-correlation integrals indeed take values between the correlation integrals of the stochastic and deterministic attractors. In noise valuation studies direct damage costs are typically estimated by using hedonic pricing or contingent valuation methods. Indirect damage costs can be approximated by estimating the resulting productivity loss. Medical costs refer to physical as well as psychiatric medical treatment. Treatment related to hearing problems caused by noise pollution but also psychiatric treatment are examples of medical costs induced by noise pollution.

5. Prevention costs

Prevention costs can be classified according to three different types of prevention measures: reduction of noise emission, reduction of noise immission and reduction of noise annoyance. Examples of prevention costs are costs related to the placement of noise control barriers, costs related to vehicle noise control, renovation costs and costs related to building relocation. Economically, only in a situation where prevention costs are lower than damage costs, preventive measures should be carried out – or at least carried out up to the point where the marginal costs of prevention become higher than the marginal damage costs. However, political interests sometimes interfere with economic principles. For example, government expenditures on prevention can be necessary to comply with noise emission standards, which may not be necessary from an economic point of view. Economic valuation of noise annoyance requires that the consequences be expressed in monetary terms. Quite often noise annoyance can only be valued indirectly, for example, by using prevention costs as a proxy. A drawback of this method is that cost calculation heavily depends on the noise limit values instituted by the government.

An interesting observation that follows from the last column is that the cost effectiveness of the construction of noise barriers is higher in situations where more stringent limit values apply. This observation is also consistent with the result the reason is that the number of buildings that are planned but cannot be constructed without noise barriers is higher in situations with more stringent limit values.

Looking at the cost-effectiveness of noise barriers on a specific railroad segment take a somewhat different approach. They assume a fixed budget and calculate a cost-benefit index for four different scenario's, in which they look at the decrease in dB(A) and the number of people that actually benefit from the noise barriers.

6. Discussion

The hedonic pricing method based on NDSI values has been used frequently in the context of airport noise evaluation and road transport noise evaluation but in the context of railway noise it has not yet been used. Cost-benefit analyses of railroad noise prevention measures sometimes use NDSI input values that are found in hedonic pricing studies on other noise sources, mostly road transport and aviation. These NDSI values vary between 0.2 % and 1.3 % [8] depending on the source. In some studies on aviation noise even values of 3.5 % are mentioned. Not all studies that use a hedonic price method use an NDSI method to identify the relationship between noise level and property value. Such a relationship can also be identified indirectly through observing the differences in property values due to railroad proximity. The result can then in a similar way be summarized as a proximity depreciation sensitivity index (PDSI). The idea is that as the distance from the railroad track increases, the level of the noise from the railroad will decrease and hence the property value depreciation will decrease. The drawbacks of NDSI studies also apply to PDSI studies. A specific disadvantage of the PDSI is that it does not take into account travel intensities or actual noise levels. Additionally, results between NDSI and PDSI studies can show variation because of the fact that the relationship between the distance to railroad track and noise level is not linear and is, moreover, disturbed by several complicating factors. A related, but less frequently used method to value noise annoyance is the contingent valuation method. Contingent valuation is based on the stated rather preference, or willingness to pay, than on revealed preference (actual behavior). The advantage of this method is that it can be applied to situations without free price formation. Also, the contingent valuation method may identify higher values that are most probably closer to the consumer surplus loss, which is not revealed by the hedonic price method [9].

This study shows another disadvantage of using contingent valuation method. The use of questionnaires necessitates to distinguish categories instead of unambiguous decibel data when formulating questions. This leads to subjectivity [7]. Also, compared to the hedonic price method the categorical approach results in a loss of informational value of the results.

7. Conclusions

The economic valuation of rail transport is economic valuation is very limited. This is primarily because compared to road and aviation transport, noise pollution of rail transport is seen as less importance. Of 17 European countries, the share of rail noise costs in total noise costs ranges from 0.5 % to 17.5 %, with an average share of 5.4 %. A noise chain system can be identified that leads from rail system characteristics, such as frequency, speed and railroad condition, via noise emission and immission to noise annoyance, and ultimately results in the economic costs of noise.

An important aspect of economic valuation of noise is the interaction between prevention costs and direct damage costs of noise pollution. Noise prevention policy can be aimed at several components of the railroad noise chain (e.g., emission and immission reduction). The inclusion of the government as a system component in the noise chain generates a feedback loop between the economic costs and the intermediate components of the noise value chain, so that the noise value chain becomes a closed system.

Government policy in this respect is often based on cost-benefit studies that analyze the trade-off mechanisms between direct costs and prevention costs. Cost-benefit studies on railroad noise policy generally use NDSI values from hedonic pricing studies on noise valuation of road transport and aviation transport as input values. The implicit assumption of transferability of such index values is not completely accurate, though. Noise is a complex multi-faceted phenomenon. The social and economic consequences of noise pollution do not just depend on the noise level (which is hard enough to measure accurately itself), but also on noise characteristics such as the type of noise, frequency, temporal distribution and subjective characteristics including attitude, habituation, activity pattern.

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